IOCG 2025 Conference

The 1st International Online Conference on Gels

03–05 December 2025 | Online

MDPI

"Formation of Olive Oil Oleogels with Anhydrous Milk Fat Fractions"

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INTRODUCTION

Driven by increasing nutritional concerns and regulatory efforts to reduce trans fatty acids and saturated fats in processed foods, alternative lipid structuring strategies have gained significant attention. Oleogelation, the immobilization of liquid oils within a gel-like network, offers a promising approach for developing semi-solid fat analogs with improved lipid profiles [1].

AIM

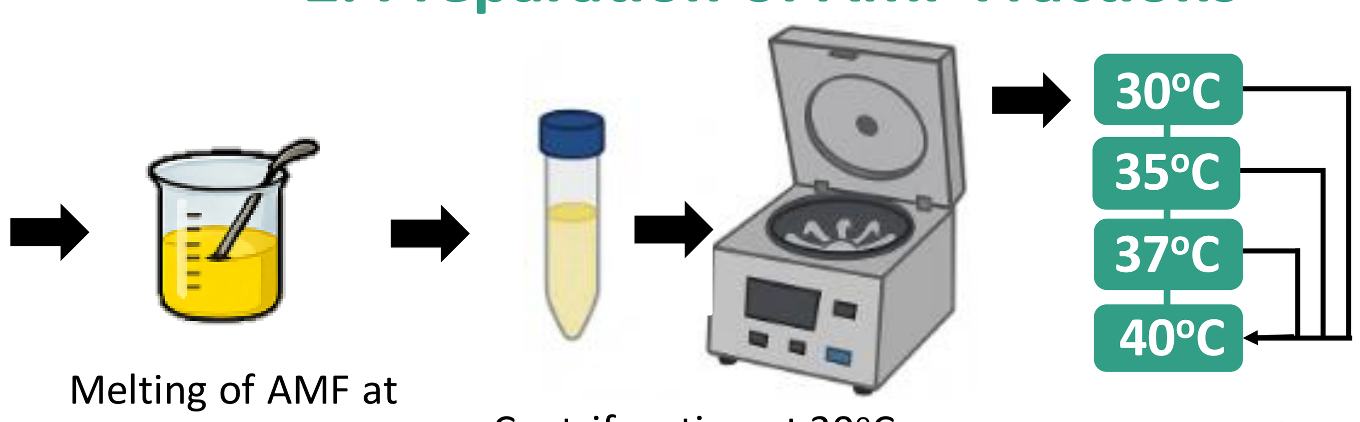
This study aimed to identify the optimal dry fractionation temperature of AMF and the minimum effective concentration required to structure olive oil into a stable oleogel. The effect of ultrasonication treatment was also examined.

METHOD

1. Materials

Olive oil & Anhydrous Milk Fat (AMF)

2. Preparation of AMF Fractions



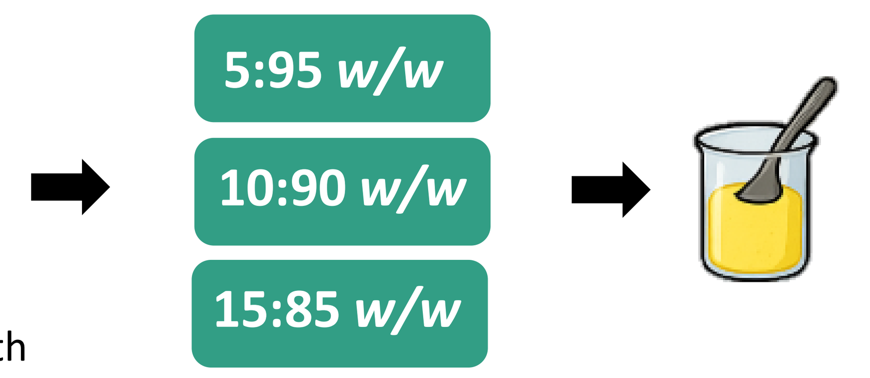
Melting of AMF at 60°C with continuous stirring & storage at 30°C for 24h

Centrifugation at 30°C, 10.000 RCF, 40min

Sequential Centrifugation of the stearin fraction at gradually increasing temperatures

3. Preparation of Oleogels

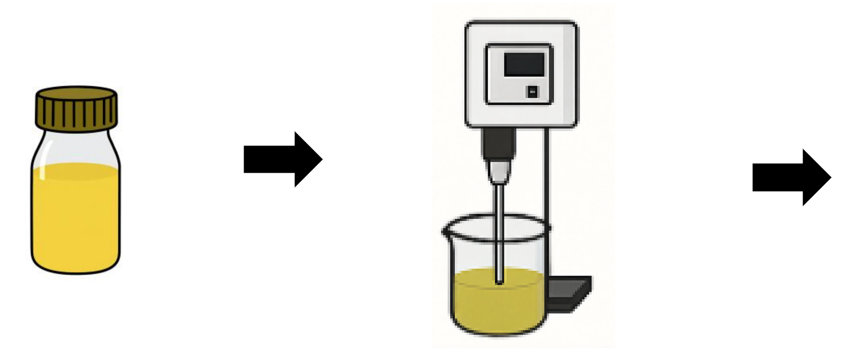
Heating at 60°C with continuous stirring of Olive oil & AMF stearin fractions obtained of each centrifugation temperature



Stearin:Olive oil mixing at different ratios

Cooling & Oleogel formation. Storage at 20°C

4. Ultrasonication Treatment



Melting of Oleogel at 60°C

Ultrasonication at 40% amplitude for a total duration of 1 min, with a 30 sec pause, while sample was placed in an ice bath. Storage at 20°C

5. Macroscopic Evaluation

6. Thermal Analysis (μDSC)

1st heating: 30°C-> 60°C
Cooling: 60°C -> -10°C
2nd heating: -10°C -> 60°C

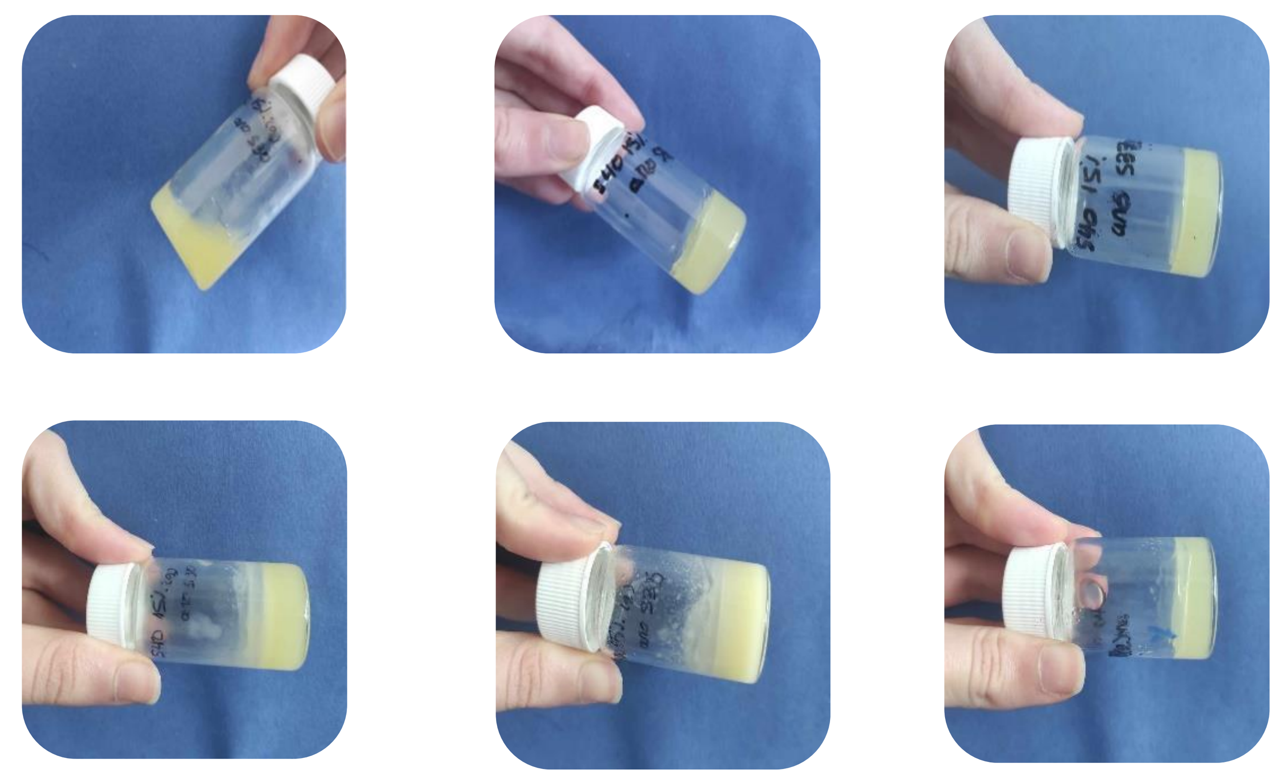
RESULTS & DISCUSSION

- The stearin fractions obtained at 35°C and 37°C and then centrifugated at 40°C were able to form self-standing oleogels (S40 35 & S40 37).
- Only the ratio 15:85 S:OO of those stearin fractions gave stable oleogels resembling the AMF structure with thermal properties close to AMF (15% S40 35 & S40 37).
- Ultrasonication improved the macroscopic self-standing behavior of the oleogels, without substantially affecting their melting temperatures, while contributing to a measurable decrease in ΔH.

S40 30 | S40 35 | S40 37

Without ultrasound treatment

With Ultrasound treatment



	Crystallization (Cooling)			Melting (2nd heating)		
	T_{on} (°C)	T_c (°C)	ΔH (J/g)	T_{on} (°C)	T_m (°C)	ΔH (J/g)
AMF	12.08 ± 0.15 c	9.87 ± 0.28 c	151.99 ± 3.25 a	21.41 ± 0.17 b	30.01 ± 0.17 c	49.67 ± 6.39 d
S40 30	13.14 ± 0.15 b	10.98 ± 0.11 b	149.34 ± 1.04 ab	25.80 ± 0.18 a	32.61 ± 0.68 b	147.20 ± 1.89 c
S40 35	13.32 ± 0.04 b	12.45 ± 0.50 b	153.65 ± 1.69 ab	25.26 ± 0.75 a	32.89 ± 0.11 b	175.09 ± 3.02 a
S40 37	14.01 ± 0.06 a	13.16 ± 0.10 a	156.18 ± 2.03 b	25.55 ± 0.12 a	33.83 ± 0.10 a	152.83 ± 1.64 b

	Without Ultrasonication 1st heating			With Ultrasonication 1st heating		
	T_{on} (°C)	T_m (°C)	ΔH (J/g)	T_{on} (°C)	T_m (°C)	ΔH (J/g)
AMF	28.66 ± 0.18 a	33.52 ± 0.09 a	94.23 ± 7.01 c	28.50 ± 0.47 a	32.01 ± 0.13 d	34.99 ± 1.83 d
S40 30	28.30 ± 0.10 a	33.45 ± 0.20 a	158.68 ± 5.04 b	28.69 ± 0.44 a	32.85 ± 0.19 c	90.73 ± 8.48 c
S40 35	28.40 ± 0.08 a	33.44 ± 0.17 a	173.77 ± 4.20 ab	28.95 ± 0.32 a	33.65 ± 0.08 b	115.10 ± 1.55 b
S40 37	28.06 ± 0.34 a	33.61 ± 0.42 a	176.71 ± 7.41 a	29.26 ± 0.52 a	34.51 ± 0.46 a	133.48 ± 11.52 a

*T_{on}, onset temperature; T_m, peak melting temperature; Tc, peak crystallization temperature.
**Values not sharing the same letter(s) within each column are significantly different by Tukey–Kramer HSD test ($P < 0.05$).

CONCLUSION

AMF fractions, particularly those isolated at higher crystallization temperatures, exhibit strong gelation capabilities in olive oil systems. Ultrasolication treatment further enhances the self-standing structure of the resulting oleogels. These oleogels may serve as viable saturated fat replacers in food formulations, pending further optimization for stability, scalability, and functional performance in real food matrices.

REFERENCES

[1] Dimakopoulou-Papazoglou, D., Zampouni, K., Prodromidis, P., Moschakis, T., & Katsanidis, E. (2024). *Microstructure, physical properties, and oxidative stability of olive oil oleogels composed of sunflower wax and monoglycerides. Gels, 10*(3), 195. https://doi.org/10.3390/gels10030195